Equipment and method of measurement in vehicle body alignment work in vehicle body measurement

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The invention relates to a measurement apparatus and method in vehicle body alignment work in measurement of a vehicle body.

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The apparatus arrangement in accordance with the invention comprises a device for alignment of a vehicle body, which device includes an alignment table to which a vehicle is attached by means of fastenings. The construction advantageously comprises a lifting gear, by means of which the alignment table can be raised to a desired alignment level. The tools to be coupled with the vehicle, such as pulling ropes or chains, can be connected to the alignment table, preferably by means of straightening booms or equivalent. The apparatus arrangement in accordance with the invention comprises a measurement apparatus that can be fitted around the vehicle to be aligned. The measurement apparatus comprises longitudinal guides on whose support a measurement arch and the measurement units associated therewith can be displaced. Perpendicularly to the centre lines X_1 of the longitudinal guides there is a transverse guide or transverse guides, which can be displaced along the longitudinal guide, having received their control from the longitudinal guide, in order to measure the constructions at the bottom of the vehicle. Said transverse guides also act as structural components interconnecting the longitudinal guides.

For the time of measurement, the vehicle is placed on the alignment table and attached to the table from the fastenings, preferably skirt fastenings or equivalent. Onto the alignment table, the measurement apparatus is fitted so that the longitudinal guides of the measurement apparatus are placed on support of the ends of the transverse beams of the alignment table, which beams are perpendicular to the longitudinal axis (X-axis) of the alignment table.

The transverse guides or beams interconnecting the longitudinal guides operate as guides for the lower measurement units connected with them. The measurement arch, and there can also be several arches, comprises a measurement unit, which can be displaced to different positions in the guides provided on the vertical beam of the measurement arch. The measurement head of the measurement unit can be displaced so that it extends to the vehicle to be aligned, placed in the middle of the measurement arch. The measurement unit of the measurement device comprises an elongated arm, which can be displaced to a desired measurement position, and the measurement value can be read from a display of an electric PC apparatus or manually from reading bars on the guides.

In accordance with the invention, a new type of measurement arrangement has been provided which is based on the use of a measurement unit that comprises a measurement arm to whose end separate arm parts are connected by means of an articulation, a measurement head being connected to the end of said arm parts. The first arm part can be moved with respect to the measurement arm in a horizontal plane and the second arm part can be turned around its longitudinal axis. Moreover, the measurement head can be positioned in different linear positions with respect to the second arm part. Advantageously, the second arm part is also movable to different linear positions with respect to the first arm part. Thus, the measurement head is provided with several different degrees of freedom, and it can also be brought to measurement points inside a vehicle. In accordance with the invention, the first arm part can be pivoted in the articulation with respect to the measurement arm such that it is locked in a given position, for example, with an angular spacing of 45°. A similar arrangement is provided for rotating the second measurement arm. The second measurement arm can be rotated around its axis preferably with a spacing of 90° so that desired locking positions are obtained with a spacing of 90°. Similarly, the measurement head can be positioned in different linear positions and also locked in a desired linear position. Said positions of the arms and of the measurement head are set in advance and they can be programmed directly into the memory of a microprocessor or a computer, thereby allowing the measurement result associated with each combination of the measurement arm positions to be obtained directly

from the computer or the microprocessor. In that case, a measurement record can also be printed immediately.

Characteristic features of the measurement apparatus and method in accordance with the invention are set forth in the claims.

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The invention will be described in the following with reference to some preferred embodiments of the invention illustrated in the figures of the accompanying drawings, to which embodiments the invention is, however, not intended to be exclusively confined.

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Figure 1A is a side elevational view of a device for alignment of a vehicle A.

Figure 1B shows the alignment device shown in Fig. 1A viewed from above.

~~Figure 2A shows a measurement device comprising a measurement frame fitted on an alignment table. Centring of the measurement device in compliance with the centre line of the vehicle is shown, and, as shown in the figure, support arms in accordance with the invention are fitted between the measurement frame and the vehicle.~~

Figure 2B shows the apparatus in accordance with the invention viewed from above, four support arms being arranged to be coupled with the vehicle to be aligned.

Figure 2C is a sectional view taken along the line I—I in Fig. 2B.

Figure 2D illustrates the apparatus arrangement shown in Fig. 2C as viewed in the direction of the arrow k_1.

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Figure 3A shows a measurement system in accordance with the invention in which a measurement head ~~64~~ 65 is connected to a measurement arm 40 through an articula-

tion 41 and arms 42 and 43. The figure illustrates the measurement device arrangement in accordance with the invention.

Figure 3B is a ~~so-called~~ an exploded view of the measurement apparatus of the invention connected to the measurement arm.

Figure 3C shows holes situated in an end face 44b of a sleeve 44, a ball/balls being positioned in said holes in locking positions.

Figure 3D is a cross-sectional view of the arm 42. It shows holes situated with an angular spacing of 90°, balls being positioned in said holes in a locking situation.

Figure 4 illustrates measurements carried out by means of the apparatus in accordance with the invention. The measurements are denoted with reference numerals 1, 2 ... and 5.

Figures 5A—5E show on an enlarged scale the measurement points shown by numerals 1—5 in Fig. 4.

As shown in Fig. 1A, the vehicle alignment device comprises an alignment table 10 shown in the figure, which table can be raised and lowered by means of a scissor jack 13 with respect to a base frame 12. The alignment device comprises transverse beams $11b_1,11b_2,11b_3$ and $11b_4$ provided in its alignment table 10, on which beams fastenings $11a_1,11a_2$... have been disposed, so that the vehicle to be aligned can be attached to the alignment table by means of the fastenings.

Fig. 1B shows the apparatus arrangement of Fig. 1A viewed from above. The alignment table 10 comprises longitudinal beams and the transverse beams $11b_1$, $11b_2,11b_3$ and $11b_4$ connected with them. The transverse beams are provided with the fastenings $11a_1,11a_2,11a_3$ and $11a_4$, from which the vehicle can be attached to the alignment table 10 for the time of alignment of the vehicle. The aligning can be carried out in the figure by means of pulling ropes or chains or similar tools, in

which connection the alignment force can be applied, for example, by means of the pulling rope or chain, for example, through a straightening boom connected with the alignment table, to the area to be straightened on the vehicle.

Fig. 2A shows a measurement device 15 as fitted on support of the alignment table 10. The measurement device 15 comprises longitudinal guides $15a_1, 15a_2$, preferably beam constructions, which are placed horizontally parallel to the longitudinal axis X of the vehicle A. Perpendicularly to the centre lines X_1 of the longitudinal guides, there are transverse guides $16a_1, 16a_2$..., preferably also beams, on which measurement units $17a_1, 17a_2$... can be placed. (As seen in Fig. 2B)

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In connection with the longitudinal guides $15a_1$ and $15a_2$, a measurement arch 15b (one or more) can be placed, which comprises vertical beams $15b_1, 15b_2$, preferably vertical guides, in which the measurement unit $17a_1, 17a_2$ is arranged to be movable in a vertical direction. The measurement unit $17a_1, 17a_2$ of the measurement device 15 further comprises a measurement arm 40 connected with said unit and displaceable with respect thereto in a horizontal plane, and a measurement head 65 in said arm. The measurement arch 15b comprises a connecting beam $15b_3$ that connects the vertical beams, i.e. the vertical guides $15b_1$ and $15b_2$ from the top. After the measurement apparatus 15 has been centred in compliance with the centre line (O-line) of the vehicle A, the vehicle can be measured at desired points by means of the measurement units $17a_1, 17a_2$ situated in connection with the measurement arch 15b mounted on the longitudinal guides $15a_1, 15a_2$ and, similarly, by means of the displaceable measurement units $17a_3, 17a_4$ provided on the transverse guides.

As shown in Fig. 2A, in accordance with the invention, a device 20 for fastening the measurement apparatus 15, preferably a support arm, is disposed between the vehicle A to be aligned and the measurement apparatus 15. Preferably, there are two fastening devices 20, preferably support arm constructions, on either side of the vehicle A. Favourably, the supporting of the measurement device on the vehicle A is carried out by means of said support arms 20 such that two support arms 20 are

supported on one transverse beam or guide $16a_1$,$16a_2$. On each side of the vehicle, one support arm 20 is supported on the vehicle from the transverse beam $16a_1$, $16a_2$... Preferably, the supporting is carried out such that the support arm is tensioned between the transverse beam $16a_1$,$16a_2$... of the measurement device 15 and the vehicle A to be straightened, which vehicle has been attached to the alignment table 10 at the fastenings $11a_1$,$11a_2$...

Fig. 2B illustrates the apparatus in accordance with the invention viewed from above. The transverse guides $16a_1$,$16a_2$, which comprise the displaceable measurement units $17a_3$,$17a_4$ (in Fig. 2A) placed on them, are disposed between the longitudinal guides $15a_1$ and $15a_2$. The transverse guides $16a_1$ and $16a_2$ are guided in the longitudinal guides $15a_1$,$15a_2$. The measurement arch 15b is also guided in the longitudinal guides $15a_1$ and $15a_2$. Also, the measurement units $17a_3$,$17a_4$ are guided in the transverse guides $16a_1$,$16a_2$. As shown in the figure, four fastening devices 20 are arranged to support the measurement frame of the measurement apparatus 15 on the vehicle A. Preferably, between the measurement apparatus 15 and the vehicle, there is a fastening device which comprises a support arm that can be tensioned between the vehicle A and the measurement apparatus 15.

Fig. 2C is a cross-sectional view taken along the line I—I in Fig. 2B at a longitudinal guide and a transverse guide. As shown in Fig. 2C, the transverse guide $16a_1$ comprises bearing means 16b which always keep the longitudinal axis y of the transverse guide $16a_1$ perpendicular to the longitudinal axes X_1 of the longitudinal guides $15a_1$,$15a_2$. As shown in Fig. 2C, the data on the position of the measurement arch 15b are read by using a detector 30 shown in the figure, which detector comprises a stepping motor 31 and an associated cogged wheel 32, which is in engagement with teeth 33 provided along the length of the longitudinal guide. When the measurement arch 15b has been positioned and calibrated initially in a certain position, the stepping motor 31 indicates the distance of shifting apart from the calibration point through a converter to a PC and further to a display. The measurement arch 15b is mounted by means of a wheel U_1 in a guide groove U_2 in the guide $15a_1$. Similarly, the measurement unit $17a_1$,$17a_2$ comprises detector means

which indicate the feed-out position of the measurement arm 40 and the height position of the measurement unit $17a_1$ in the vertical guide $15b_1,15b_2$.

Fig. 2D illustrates the apparatus viewed in the direction of the arrow K_1 in Fig. 2C, i.e. from above. The transverse guide $16a_1,16a_2$... comprises a plate part 16d situated at its ends perpendicularly to its bridge beam 16c, which plate part 16d includes a number of bearings 16b, which are fitted in said plate part 16d and arranged to travel along with the plate part in a longitudinal guide groove U_3 in the longitudinal guide $15a_1$.

Fig. 3A illustrates the apparatus in accordance with the invention in different positions of a pivotable arm 42. The first arm part 42 is connected to the measurement arm 40 by means of an articulation 41, a second arm part 43 being further connected to said first arm part. A measurement head ~~64~~ 65 is connected to the second arm part 43. The measurement head ~~64~~ 65 is brought into contact with the point to be measured. As shown in the figure, the arm part 42 can be turned by means of the articulation 41 to different locking positions, advantageously to different locking positions with an angular spacing of 45°. Similarly, the second arm part 43 can be rotated around its longitudinal axis X_{30} to different angular positions/locking positions. Advantageously, there are such angular/locking positions with an angular spacing of 90°. The arm part 42 is arranged to pivot in a horizontal plane. The measurement arm 40 is moved as shown by the arrow S_1 with respect to the measurement unit $17a_1$ which measures the exact feed-out position of the measurement arm 40 (As seen in Fig. 3B). The height position of the measurement unit $17a_1$ in the vertical guide $15a_1$ is also measured by the detector means of the measurement unit $17a_1$. Moreover, the vertical guide $15a_1$ can be placed in different positions with respect to the longitudinal axis X of the vehicle on the side of the vehicle. Said angular position can be measured separately, as shown in the embodiment of Fig. 2C.

Each part of the mechanism has its own locking position. Thus, when storing in the memory of a computer the positions of the arm part 42 or the second arm part 43 following after it and of the associated measurement head ~~64~~ 65 the position of the tip

of the measurement head can immediately be calculated by means of a program stored in the memory of the computer. Thus, the measurement result related to a given combination of positions can be read directly from a display of the computer and/or printed from a printer of an output device as a measurement record.

In accordance with the invention, it is also possible to use a device arrangement in which detector means detect, at a given time, the locking position of each part, such as the arm part 42, the second arm part 43 and the measurement head ~~64~~ 65, and the data in question are electrically supplied directly into the memory of the computer which indicates a reading of the measurement head corresponding to the combination detected.

Fig. 3B shows the measurement arm 40 associated with the measurement apparatus in accordance with the invention comprising the articulation 41 at its end. The longitudinal axis of the measurement arm 40 is designated by X_{10}. The arm part 42 is connected to the measurement arm 40 through the articulation 41. The arm part 42 is a hollow structure and includes an inner space D which is closed by a cover ~~42a~~ 54 at one end. The longitudinal axis of ~~the arm part 42~~ A second arm part 43 is designated by X_{20}. ~~The arm part 43~~ A second arm part 43 is connected to the first arm part 42. Said second arm part 43 can be turned around its longitudinal axis X_{30}. The measurement head 65 can be passed through a through hole 64 in the second arm part 43. Thus, the tip J, or the reading head, of the measurement head 65 has several degrees of freedom. The measurement head 65 can be displaced linearly in the direction of its longitudinal axis X_{40}, which axis X_{40} is perpendicular to the axis X_{30}. The geometric longitudinal axis of the through hole 64 is perpendicular to the axis X_{30}. To begin with, the tip J can be raised and lowered in the vertical guides of the measurement arch and moved in the longitudinal or horizontal guides to different positions with respect to the longitudinal axis X of the vehicle. In addition, the measurement arm 40 can be moved in the direction of its longitudinal axis X_{10} to different positions towards and away from the vehicle. The first arm part 42 can be pivoted with respect to the articulation 41 such that the arm part 42 turns in the horizontal plane to different angular positions. A backing body 48 and the associated arm part 42 can be pivoted around a geomet-

ric axis Y_1, which axis Y_1 is perpendicular to the longitudinal axis X_{10} of the measurement arm 40. Advantageously, there are several angular positions with a spacing of 45°. In addition, the second arm part 43 can also be turned around its longitudinal axis X_{30} preferably with an angular spacing of 90°. Furthermore, the measurement head 65 can be positioned linearly in the direction of its axis X_{40} to different positions with respect to the second arm part 43.

The articulation 41 is formed of a sleeve 44 comprising a hollow inner space E. At the end of the sleeve 44 there is a cover 44a which closes the inner space E. On an end face 44b of the sleeve 44 there are situated holes $45a_1$,$45a_2$,$45a_3$... with a spacing of 45° or another regular number of degrees. Balls $46a_1$,$46a_2$... which are arranged to be pressed by springs $47a_1$,$47a_2$ are situated in holes $49a_1$,$49a_2$... of the backing body 48. Thus, the backing body 48 can be pivoted to a desired angular position with respect to the sleeve 44, which sleeve 44 is firmly attached to the measurement arm 40. A fixing bolt 50 is passed through a hole 48c provided in the pivotable backing body 48 and further through a hole 44c of the sleeve 44, and thus a nut 52 presses the backing body 48 against the end face 44b of the sleeve 44. The balls $46a_1$,$46a_2$... remain between the end face 44b of the sleeve 44 and an end face 48b of the backing body 48. The desired adjustment force for pivoting the backing body 48 is regulated by adjusting the tension of the nut 52 with the screw 50. The angular spacing of the holes $45a_1$,$45a_2$... determines the accuracy of adjustment. Advantageously, the angular spacing of the holes $45a_1$,$45a_2$... is 45°.

Screws $53a_1$ and $53a_2$ fasten the arm part 42 to the backing body 48. The screws $53a_1$,$53a_2$ are passed through the wall of the arm part 42 and their heads are thus situated in the inner space D of the arm part 42. The cover 54 closes the hollow inner space D of the arm part 42.

The first arm part 42 after the articulation 41 comprises first holes $55a_1'$,$55a_1$...; $55a_2'$,$55a_2$... in pairs, which holes in pairs are preferably provided with an angular spacing of 90°, and the holes have been made through the wall of the first arm part 42. Said first holes $55a_1'$;$55a_1$ are situated at the end of the arm part 42 on the side

of the articulation 41, and second holes $56a_1'$,$56a_1$; $56a_2'$,$56a_2$... in pairs, also with an angular spacing of 90°, are situated at the other end of the arm part 42. The arm part 42 additionally comprises at its end a tapering end thread 57 with a nut 59 placed onto it, a tension sleeve 58 being situated between the nut 59 and the second arm part 43.

As shown in Fig. 3B, the second arm part 43 is placed in the inner space D of the first arm part 42 as shown by the arrow L_1 such that springs $61a_1$, $61a_2$ and balls $62a_1$,$62a_2$... situated in holes $60a_1'$,$60a_1$;$60a_2'$,$60a_2$... at the end of the second arm part 42 will be cooperative with the holes $55a_1'$,$55a_1$;$55a_2'$,$55a_2$ ... or $56a_1'$,$56a_1$... of the first arm part 42. The springs $61a_1$ and $61a_2$ and the balls $62a_1$,$62a_2$... are cooperative with the holes $56a_1'$,$56a_1$,$56a_2'$,$56a_2$ or with the holes $55a_1'$,$55a_1$;$55a_2'$, $55a_2$ at either end of the first arm part 42, i.e. the first arm part can be placed by a linear movement L_1 to alternative length positions with respect to the first arm part 42. The balls $62a_1$,$62a_2$... are preferably situated on the opposite sides of the arm 43, in their holes $56a_1'$,$56a_1$..., into which the springs $61a_1$,$61a_2$... are placed.

The end of the second arm part 43 advantageously includes an end piece 600, which is a plastic part placed at its shoulder to the end of an arm part 430 proper which is made of metal. By using a plastic part, advantageous bearing properties are imparted to the balls, and there is no need for lubrication. The sleeve 600 is preferably attached by a cotter 63 to said metal portion 430 of the second arm part 43.

An end piece 700 is connected to the metal portion 430 at the other end of the second arm part 43, said end piece 700 comprising a through hole 64 whose centre axis is perpendicular to the longitudinal axis X_{30} of the second arm part 43 and through which through hole 64 the measurement head 65 is passed. The measurement head 65 comprises grooves $66a_1$,$66a_2$... in spaced relationship with one another. Further, the structure comprises an end stub 67 into whose inner hole 68 a ball 69 and a spring 70 are placed. A screw 71 is arranged to press the spring. The force by which the spring 70 presses the ball 69 against one of the grooves $66a_1$ or $66a_2$... in the measurement head 65 can be regulated by turning the screw 71. By

displacing the measurement head 65 in the through hole 64, the measurement head can be brought to alternative positions $66a_1$ or $66a_2$... A protective cover 72 is provided around the end stub 67. When needed, an extension arm can also be attached to the end stub 67.

As shown in Fig. 3C, the holes $45a_1$,$45a_2$... are situated with a angular spacing of 45° on the end face 44b of the sleeve 44. The balls $46a_1$,$46a_2$ are positioned in the holes $45a_1$,$45a_2$,$45a_3$... in a locking situation.

In the arrangement in accordance with the invention, the first arm part 42 can be displaced in a horizontal plane with respect to the measurement arm 40 by means of the articulation 41 to different locking positions which may be provided with a spacing of 45°. Similarly, the second arm part 43 connected to the first arm part 42 can be turned around its longitudinal axis to different angular and locking positions provided, for instance, with a spacing of 90°. Similarly, the measurement head 64 can be positioned linearly in different positions. Said position data can be programmed directly into the memory of a computer, and the precise position of the tip J of the measurement head 65 can be calculated geometrically by means of a program stored in the memory. Thus, when the different positions of the measurement arms 42,43 have been preprogrammed into the memory of the computer, the computer directly shows the measurement result related to said combination of the measurement arm positions on the display of the computer, and/or said measurement result can be printed directly as a measurement record.

In accordance with the invention, the first arm part 42 associated with the articulation 41 and the second arm part 43 connected to the first arm part as well as the measurement head 65 connected to the second arm part can also be provided with electrical means which indicate the positions of the arm parts 42,43 and the measurement head 65 directly to a computer, which stores them in the memory of the computer and further indicates the exact coordinates of the measurement tip J in three-dimensional space. Different position detectors may be used for indicating the

data on the position of the measurement head 64 of the arm parts 42 and 43 directly to the computer.

Fig. 3D shows the holes $56a_1, 56a_2$ of the arm 42 into which the balls $62a_1, 62a_2$... are pressed by the springs $61a_1, 61a_2$ in any given locking situation. The holes are provided with an angular spacing of 90°, thereby enabling the arm 43 to have eight different locking positions when turning it around its longitudinal axis X_{30}.

Fig. 4 shows different measurement points of the measurement arm 40 in accordance with the invention in connection with a vehicle to be repaired. The measurement points are denoted with reference numerals 1,2,3,4 and 5 in the figure. Figs. 5A, 5B,5C,5D, and 5E are enlarged views of the corresponding points of the measurement head.

Fig. 5A shows angular measurement of a roof going on to ensure the correct dimensioning of window and door openings. Fig. 5B shows measurement of the attachment points for rear suspension in the interior of a car, which is made possible by the turning measurement head in accordance with the invention. Fig. 5C shows measurement of the upper end of suspension, which is one of the most important measurement points. Fig. 5D shows measurement of a vertical pillar, which often also includes measurement of the locations of bolts for fastening rear doors.

Fig. 5E shows measurement of the location of a bolt for fastening a lower support arm which affects the driving characteristics.